CARDIOVASCULAR MEDICINE

Decline in incidence of hospitalisation for acute myocardial infarction in the Netherlands from 1995 to 2000

H L Koek, A de Bruin, A Gast, E Gevers, J W P F Kardaun, J B Reitsma, D E Grobbee, M L Bots

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See end of article for authors' affiliations

Correspondence to: Dr M L Bots, Julius Centre for Health Sciences and Primary Care, University Medical Centre Utrecht, HPN Str 06.131, PO Box 85.060, 3508 AB, Utrecht, Netherlands; m.l.bots@umcutrecht.nl

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Objective: To study the change in incidence of hospitalisation for a first acute myocardial infarction (AMI) in the Netherlands from 1995 to 2000.
Methods: Patients hospitalised with their first AMI in the Netherlands in 1995 and 2000 were identified through linkage of the national hospital discharge register and the population register.
Results: 21 565 patients hospitalised for their first AMI in 1995 and 19 058 patients hospitalised for their first AMI in 2000 were identified. In both years, the age specific incidence of hospitalisation for a first AMI was higher in men than in women and increased with age (up to 90 years). In both men and women, the age standardised incidence was lower in 2000 than in 1995, a decline of 19% (95% confidence interval 17% to 21%) and 17% (95% confidence interval 14% to 19%), respectively.
Conclusions: Our study provides the first nationwide incidence estimates of first AMI in the Netherlands. From 1995 to 2000, the risk of AMI declined considerably.

Mortality from coronary heart disease (CHD) has declined during the past decades in many western countries.[1 2] A decrease in CHD mortality is a consequence of a decrease in incidence, case fatality, or recurrence risk or a combination of these. Data from the World Health Organization MONICA (monitoring trends and determinants in cardiovascular disease) project, studying population samples from 21 countries, have suggested that in populations in which CHD mortality decreased, coronary event rates contributed two thirds and case fatality one third.[3] Only a few countries provide nationwide data on the incidence of acute myocardial infarction (AMI). Many other countries, including the Netherlands,[4] have to rely on regional registries. However, after we recently showed that patients could validly be followed up within Dutch national (medical) registrations,[5] we set out to study the nationwide incidence of hospitalisation for first AMI, with emphasis on the change in incidence from 1995 to 2000.

METHODS

Data sources

Cases of first hospitalisation for AMI were identified by linkage of the Dutch national hospital discharge register with the Dutch population register. The hospital discharge register provides complete nationwide coverage of data on hospital admissions since 1986. For each admission, a principal diagnosis is determined at discharge by the treating physician and coded by local hospital staff according to the *International classification of diseases*, ninth revision, clinical modification (ICD-9-CM).[6] A single institution is responsible for training hospital staff in coding. As the hospital discharge register does not contain a unique personal identifier, we tracked individual patients over time within the hospital discharge register by using information from the population register. The population register contains actual demographic information on all registered people living in the Netherlands. All analyses were performed in agreement with privacy legislation in the Netherlands at Statistics Netherlands.[5]

Cohort enrolment

In the hospital discharge register, 27 912 and 24 954 hospital admissions with a principal diagnosis of AMI (ICD-9-CM code 410) were registered in 1995 and 2000, respectively. After linkage with the population register by the linkage variables date of birth, sex, and numerical part of postal code, 25 142 and 22 470 admissions of patients with a unique combination of linkage variables remained (90%). Admissions linking with more than one person (administrative twins; two persons with the same date of birth, sex, and numeric part of postal code in the population register (7% in both years)) or with no person at all (for example, for foreign visitors or illegal immigrants (3% in both years)) were excluded. Selection of the first admission of all subsequent admissions of a person during 1995 and 2000 yielded 23 172 patients in 1995 and 20 414 patients in 2000. Thus, 1970 readmissions for an AMI had occurred in 1995 (8%) and 2056 in 2000 (9%). Information on previous admissions of the patients in 1995 and 2000 was obtained by linkage with the hospital discharge registers of 1991–1995 and 1995–2000, respectively. Patients with previous hospital admissions for AMI were excluded (7% in both years). This resulted in the final cohort of 21 565 patients in 1995 and 19 058 patients in 2000.

Data analysis

The incidence of hospitalisation for a first AMI in 1995 and 2000 (with 95% confidence interval (CI)) was computed by age and sex. Numbers of unique patients (unique in the population on the combination of values of the linkage variables) in the population register at 1 July in 1995 and in 2000 were used as an estimate of person years at risk. The age standardised incidence (with 95% CI) was computed by

Abbreviations: AMI, acute myocardial infarction; CHD, coronary heart disease; CI, confidence interval; ICD-9-CM, *International classification of diseases*, ninth revision, clinical modification; MONICA, monitoring trends and determinants in cardiovascular disease direct standardisation to the mean of the mid year age distribution of men and women in the Dutch population of 2000. Incidence ratios (with 95% CI) were calculated to compare the incidence of men and women and the (age standardised) incidence in 2000 and 1995. The 95% CIs were estimated assuming that the observed number of cases followed a Poisson distribution.[7] Data were statistically analysed with SPSS software, version 12.0 (SPSS Inc, Chicago, Illinois, USA).

RESULTS

Table 1 gives general characteristics for both 1995 and 2000. Two thirds of the patients were men. In 1995, men were on average 7.6 years younger than women. In 2000, this difference was 7.4 years. The mean length of hospital stay was 10 days in 1995 compared with nine days in 2000.

Among men the incidence (per 100 000 person years) was 221 in 1995 and 190 in 2000, and among women, 106 in 1995 and 91 in 2000 (table 2). For both sexes, the incidence increased with age up to 90 years (up to 80 years among men in 1995). In both years, the incidence was significantly higher among men than among women in all age groups (except for the age group $\geqslant$ 90 years in 2000). The incidence was lower in 2000 than in 1995 in all age groups $\geqslant$ 40 years among men and from 50–90 years among women. Among women aged $<$ 30 years, the incidence in 2000 was three times higher than in 1995, but the number of patients was very small ($n = 17$). Among women aged 40–49 years, the incidence increased 18% (95% CI 1% to 37%) from 1995 to 2000.

The age standardised incidence (per 100 000 person years) of hospitalisation for a first AMI was 140 (95% CI 138 to 142) in 2000 compared with 171 (95% CI 168 to 172) in 1995, a decline of 18% (95% CI 16% to 20%). Among both men and women, the age standardised incidence was lower in 2000 than in 1995, a decline of 19% (95% CI 17% to 21%) and 17% (95% CI 14% to 19%), respectively.

DISCUSSION

Our study provides the first nationwide evidence that the incidence of first AMI declined by 19% in men and 17% in women in the Netherlands from 1995 to 2000. This decline was seen in all age groups $>$ 40 years in men and from 50–90 years in women.

Strengths and limitations

Some aspects of the study need to be addressed. We excluded non-uniquely linked hospital admissions. A pilot study suggested that non-uniqueness relates to large cities, foreign origin, and age.[5] The differences between unique and non-unique people, however, were small[8] and apply to both 1995 and 2000. Moreover, substantial bias in the trends is probably prevented by excluding non-uniquely linked admissions in both years and by excluding non-unique people in the estimates of person years at risk in both years.

The strength of our study relies on the validity of the registries and linkage methods and the large size and lack of selection of the cohorts. Recently, it was shown that 99% of the personal, admission, and discharge data and 84% of the principal diagnoses (validated through medical record review by medical specialists) were correctly registered in a random sample of all hospital admissions registered in the hospital discharge register (for admissions both with and without surgical interventions).[9] Furthermore, over 97% of the uniquely linked hospital admissions resulting from linkage of the hospital discharge register with the population register were shown to be correctly linked.[8]

Comparison with other studies

Several other studies estimated trends in incidence of AMI in the 1990s. However, comparison requires caution due to methodological differences (differences in data collection, study population, case definition, or research period). Linnersjö *et al*[10] identified 50 000 new cases of first AMI (hospital discharges and deaths) in Stockholm county from 1984–1996 and found a significant annual decline in age standardised incidence of 2% (95% CI 1.7% to 2.2%) among men and 1% (95% CI 1.1% to 1.8%) among women. In Finland, a significant annual decline in incidence of first CHD (hospital admissions and deaths) of 4% (95% CI −4.7 to −3.3) was shown among 170 000 residents in three towns from 1983–1997.[11] In the USA, a relatively stable age adjusted incidence of first hospitalised AMI was observed among 360 000 men and women in four communities from 1987–1996 (annual increase of 1.1% (95% CI 0.0% to 2.1%) in men and of 1.7% (95% CI −0.1% to 3.4%) in women).[12]

The decline in hospital stay shown in this study is consistent with our previous findings.[1] From 1980–2000, we found a decline in hospital stay for (first and recurrent) AMI from 18 to 10 days. Improvements in management, including increased use of coronary reperfusion modalities, may have contributed to this decline.

Factors contributing to AMI trend

The changes we observed may reflect a real decline in incidence but may also be attributed to a change in risk of death before hospitalisation, in referral pattern of the general

Table 1 Characteristics of patients hospitalised for a first acute myocardial infarction (AMI) in the Netherlands in 1995 and 2000

	Men		Women		Total	
	1995	2000	1995	2000	1995	2000
Number of patients	14463	12783	7102	6275	21565	19058
Age at admission (years)						
Mean (SD)	64.3 (12.3)	64.2 (12.7)	71.9 (11.8)	71.6 (12.8)	66.8 (12.6)	66.7 (13.2)
Median	65.3	65.0	73.4	73.8	68.0	68.0
Type of hospital						
Academic	6.2%	7.5%	5.7%	6.2%	6.0%	7.0%
General	93.8%	92.5%	94.3%	93.8%	94.0%	93.0%
Length of stay (days)						
Mean (SD)	9.8 (7.5)	8.9 (8.4)	10.9 (10.1)	10.0 (10.7)	10.1 (8.5)	9.2 (9.3)
Median	9.0	7.0	9.0	8.0	9.0	8.0
C25–C75*	6.0–12.0	5.0–10.0	6.0–13.0	5.0–12.0	6.0–12.0	5.0–11.0
Origin						
Native	89.3%	88.3%	90.0%	88.4%	89.6%	88.4%
Non-native	10.7%	11.7%	10.0%	11.6%	10.4%	11.6%

*25th to 75th centile.

Table 2 Incidence (per 100 000 person years) of hospitalisation for a first AMI by age and sex in the Netherlands in 1995 and 2000

	1995			2000			2000/1995
Age (years)	Patients*	Population at risk†	Incidence (95% CI)	Patients*	Population at risk†	Incidence (95% CI)	IR‡ (95% CI)
Men							
<30	28	2654358	1.1 (0.7 to 1.4)	37	2576315	1.4 (1.0 to 1.9)	1.36 (0.83 to 2.22)
30–39	337	1057764	32 (29 to 35)	356	1098227	32 (29 to 36)	1.02 (0.88 to 1.18)
40–49	1747	1007599	173 (165 to 182)	1 450	1011713	143 (136 to 151)	0.83 (0.77 to 0.89)
50–59	3030	740283	409 (395 to 424)	2 960	892870	332 (320 to 344)	0.81 (0.77 to 0.85)
60–69	4223	576479	733 (711 to 755)	3 344	606735	551 (533 to 570)	0.75 (0.72 to 0.79)
70–79	3661	362702	1009 (977 to 1042)	3 291	399574	824 (796 to 852)	0.82 (0.78 to 0.86)
80–89	1345	128657	1045 (990 to 1101)	1 276	138020	925 (874 to 975)	0.88 (0.82 to 0.95)
⩾90	92	13943	660 (525 to 794)	69	14886	464 (354 to 573)	0.70 (0.51 to 0.96)
All ages	14463	6541785	221 (218 to 225)	12 783	6738340	190 (186 to 193)	
Women							
<30	4	2552064	0.2 (0.0 to 0.3)	13	2485992	0.5 (0.2 to 0.8)	3.34 (1.09 to 10.2)
30–39	82	1025600	8 (6 to 10)	90	1067573	8 (7 to 10)	1.05 (0.78 to 1.42)
40–49	313	975229	32 (29 to 36)	374	989158	38 (34 to 42)	1.18 (1.01 to 1.37)
50–59	682	721322	95 (88 to 102)	692	867587	80 (74 to 86)	0.84 (0.76 to 0.94)
60–69	1645	627180	262 (250 to 275)	1 250	637725	196 (185 to 207)	0.75 (0.69 to 0.80)
70–79	2442	502222	486 (467 to 506)	2 108	531798	396 (380 to 413)	0.82 (0.77 to 0.86)
80–89	1732	273244	634 (604 to 664)	1 533	283866	540 (513 to 567)	0.85 (0.80 to 0.91)
⩾90	202	46337	436 (376 to 496)	215	54502	394 (342 to 447)	0.90 (0.75 to 1.10)
All ages	7102	6723198	106 (103 to 108)	6 275	6918201	91 (89 to 93)	

*Number of patients hospitalised for a first AMI (records that uniquely linked with the population register); †number of (unique) people in the population register at 1 July 1995 and 2000, respectively; ‡incidence ratio (IR) of the incidence in 2000 to that in 1995.
CI, confidence interval.

practitioner, in diagnostic criteria, or in classification policy at the hospital.

Several studies showed a declining trend in risk of death before hospitalisation during the 1990s.[13 14] Although data have not been collected for the Netherlands, the existence of a similar or stable trend would not explain the decline in incidence.

In the present study, we assumed that any changes in referral pattern by the general practitioners during the relative short study period were probably too small to affect the incidence trends. Non-referral of patients with a non-fatal AMI is negligible in the Netherlands, as unpublished data from the Rotterdam Study of 7983 men and women aged ⩾ 55 years showed that only 1.7% of all patients with non-fatal AMIs were not hospitalised (J C M Witteman, personal communication, 2004).[15]

The diagnostic criteria of AMI applied in 1995 probably differed from those in 2000. The application of new, more sensitive criteria (including assessment of troponin) may have shifted diagnoses from unstable angina pectoris to AMI.[16] Furthermore, diagnostic improvements during the study period might have reduced the proportion of unrecognised (silent) infarctions.[17] Both phenomena would have led to an increase in incidence rather than a decline.

In both 1995 and 2000, disease was coded in the hospital discharge register according to the ICD-9-CM. Since a single institution is responsible for training hospital staff in coding, any changes in coding of AMI are likely to be small. Furthermore, our data showed that AMI constituted 30% and angina pectoris 39% of CHD in the hospital discharge register in 1995. Corresponding figures in 2000 were 31% and 40%.[1] Therefore, a substantial shift is unlikely.

In conclusion, the decline in incidence between 1995 and 2000 appears to reflect a real decline in incidence of AMI in the Netherlands. This decline may be attributed to favourable changes in risk factors, as some beneficial changes occurred during the 1990s (for example, declining hypercholesterolaemia prevalence). Other risk factors, however, remained constant (such as hypertension) or even increased (overweight and obesity).[18]

Conclusion

Our study provides, for the first time, nationwide incidence estimates of hospitalisation for first AMI in the Netherlands. The results of this study show a considerable decline in risk of AMI between 1995 and 2000.

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Authors' affiliations

H L Koek, D E Grobbee, M L Bots, Julius Centre for Health Sciences and Primary Care, University Medical Centre Utrecht, Utrecht, the Netherlands
A de Bruin, A Gast, J W P F Kardaun, Statistics Netherlands, Voorburg, the Netherlands
E Gevers, Prismant, Utrecht, the Netherlands
J B Reitsma, Department of Clinical Epidemiology and Biostatistics, Academic Medical Centre, Amsterdam, the Netherlands

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IMAGES IN CARDIOLOGY

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Use of magnetic resonance imaging in the diagnosis of aneurysm of fossa ovalis

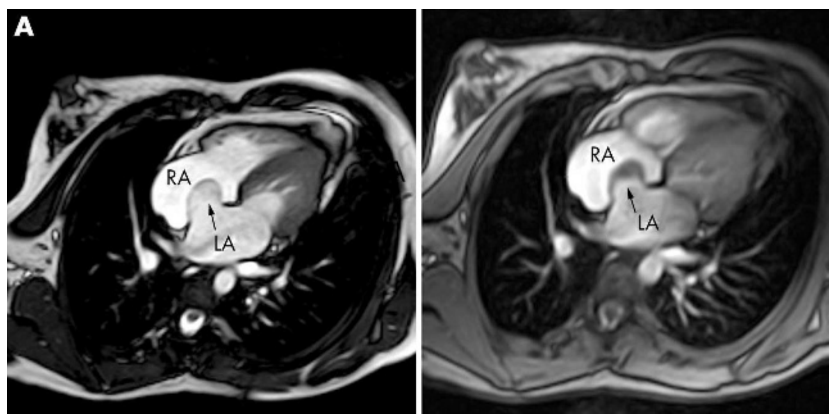
A 15 year old active female with a clinical transient ischaemic attack was referred to our institute to rule out a cardioembolic origin to the episode. Magnetic resonance (MR) imaging revealed a mobile atrial septal aneurysm into the right atrium during systole with a 17 mm protrusion beyond the plane of the interatrial septum and a diameter of the base of aneurysm portion of the interatrial septum of 16 mm (panels A and B, videos 1 and 2: to view video footage visit the *Heart* website—http://www.heartjnl.com/supplemental). The use of high resolution cine gradient echo sequence is particularly sensitive for detecting slow flow and is able to differentiate it from a mass. The aneurysm of the fossa ovalis in this sequence showed slow flow and it might indicate the possibility of formation of thrombi in the saccular cavity (panel A)

Aneurysm of the fossa ovalis is a protruding, space occupying, atrial septal structure clinically identified by serial imaging modalities. An association between atrial septal aneurysm and focal cerebral ischaemic events (stroke and transient ischaemic attack) has been suggested. Nevertheless, the role of aneurysm of the fossa ovalis as a risk factor for cerebral ischaemia is poorly defined. MR imaging techniques such as phase contrast sequences allow quantification of blood velocity profiles through these septal defects at different times during the cardiac cycle.

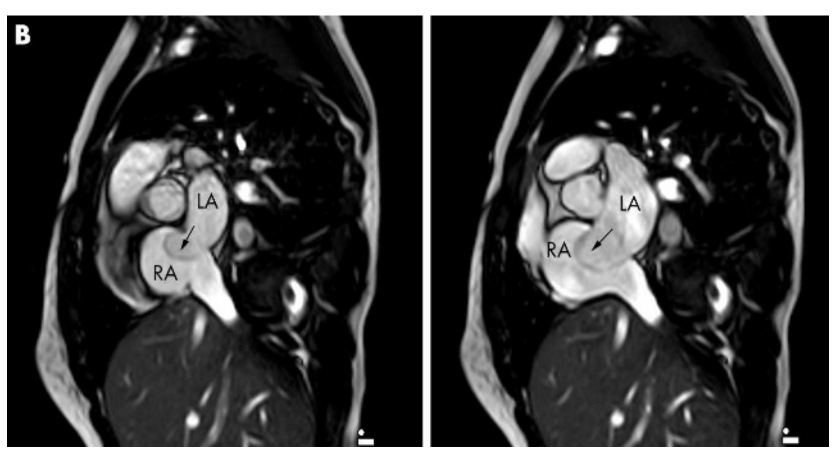
This case indicates the potential of cardiac MR imaging in the evaluation of aneurysm of the fossa ovalis as a potential source of embolism.

A Sonlleva
P Robles
J Parra
probles@fhalcorcon.es

To view video footage visit the *Heart* website—http://www.heartjnl.com/supplemental



Left: Cine gradient sequence in four chamber view showing a mobile atrial septal aneurysm into the right atrium (arrows). Right: Same plane with slow flow effect in the saccular cavity. LA, left atrium; RA, right atrium.



Left: Cine gradient sequence in systolic sagittal view. Right: Cine gradient sequence in diastolic sagittal view showing atrial septal aneurysm (arrows).